Smart High-Side Power Switch for Industrial Applications One channel: 1 x 1 Ω

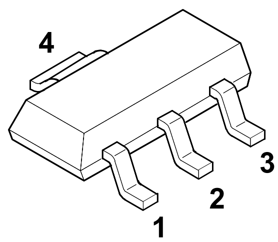
Product Summary

Overvoltage protection	$V_{bbin(AZ)}$	62	V
Operating voltage	$V_{bb(on)}$	4,9...60	V
On-state resistance	R_{ON}	1	Ω
Operating Temperature	T_a	-30 … +85	°C

Features

- Current controlled input
- Short circuit protection
- Current limitation
- Overload protection
- Overvoltage protection (including load dump)
- Switching inductive loads
- Clamp of negative voltage at output with inductive loads
- Thermal shutdown with restart
- ESD – Protection
- Loss of GND and loss of V_{bb} protection
- Very low standby current
- Reverse battery protection
- Improved electromagnetic compatibility (EMC)

PG-SOT223



Application

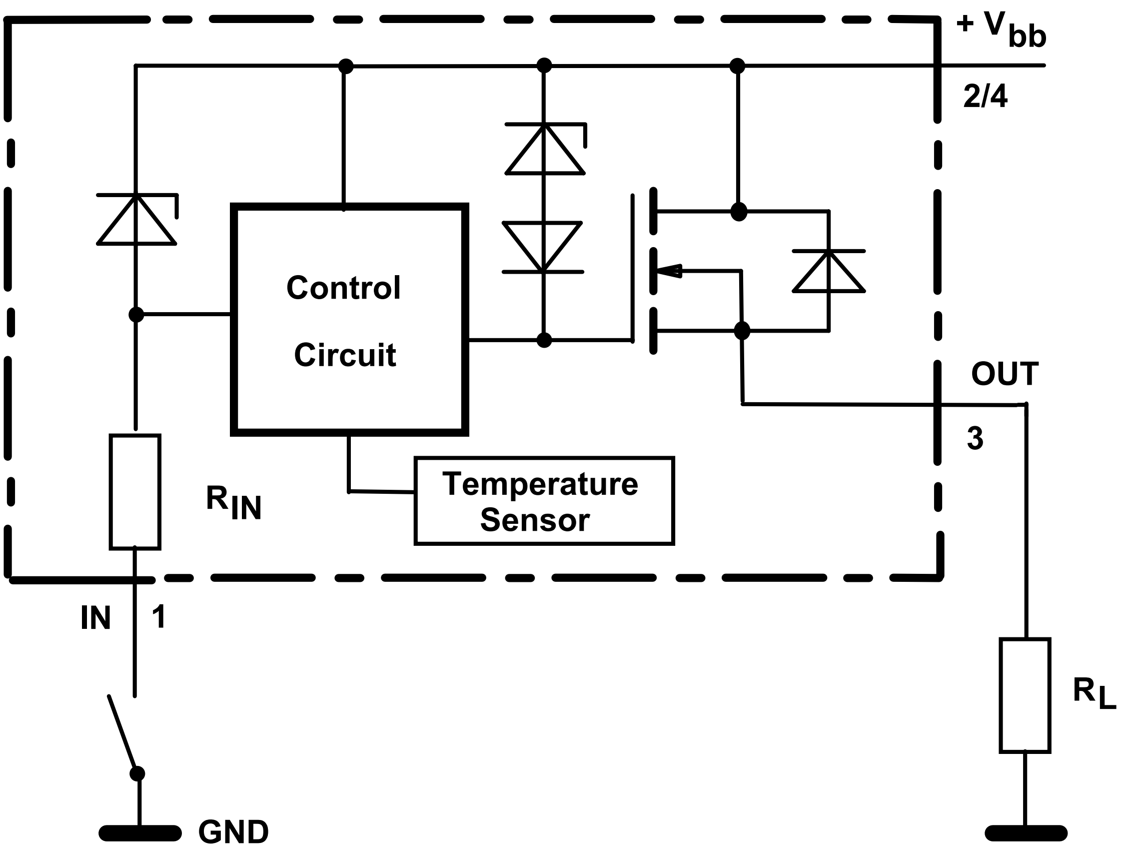
- All types of resistive, inductive and capacitive loads in industrial applications
- Current controlled power switch for 12V, 24V and 42V DC industrial applications
- Driver for electromagnetic relays
- Signal amplifier

General Description

- N channel vertical power MOSFET with charge pump and current controlled input, monolithically integrated in Smart SIPMOS® technology.
- Providing embedded protection functions.

Type	Ordering code	Package
ITS 4140N	**SP000240073**	PG-SOT223

Block Diagram



Pin	Symbol	Function
1	IN	Input, activates the power switch in case of connection to GND
2	Vbb	Positive power supply voltage
3	OUT	Output to the load
4	Vbb	Positive power supply voltage

Maximum Ratings

Parameter at T_j = 25°C unless otherwise specified	**Symbol**	**Values**	**Unit**
Supply voltage	V_{bb}	60	V
Load current (Short – circuit current, see page 5)	I_L	self limited	A
Maximum current through the input pin (DC)	I_{IN}	±15	mA
Junction temperature Operating temperature range Storage temperature range	T_j T_a T_{stg}	+150 -30 … +85 -40 ...+105	°C
Power dissipation[1)] T_a = 25 °C	P_{tot}	1.7	W
Inductive load switch-off energy dissipation[2)] Single pulse T_j = 150°C, I_L = 0.15A	E_{AS}	1	J
Load dump protection[3)] $V_{LoadDump}$[4)] = V_A + V_S R_L=2Ω, t_d = 400ms, V_{IN} = low or high I_L = 150mA, V_{bb} = 13.5V V_{bb} = 27V	$V_{LoadDump}$	 93.5 127	V
Electro**s**tatic **d**ischarge voltage (Human Body Model) According to ANSI EOS/ESD – S5.1 – 1993 ESD STM5.1 – 1998 Input pin all other pins	V_{ESD}	 ±1 ±5	kV

[1] Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6 cm2 (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air.

[2] Not subject to production test, specified by design

[3] More details see EMC-Characteristics on page 7

[4] $V_{LoadDump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839.

Electrical Characteristics

Parameter at T_j = -40...150 °C, V_{bb} = 9...42 V unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
Thermal Characteristics					
Thermal resistance @ min. footprint	$R_{th(JA)}$	-	86	125	K/W
Thermal resistance @ 6 cm² cooling area [1]	$R_{th(JA)}$	-	60	72	
Thermal resistance, junction - soldering point	R_{thJS}	-	-	17	K/W

Load Switching Capabilities and Characteristics

Parameter	Symbol	min.	typ.	max.	Unit
On-state resistance Pin1 connected to GND	R_{ON}				Ω
T_j = 25 °C, I_L = 150 mA, V_{bb} = 9...52 V		-	1	1.5	
T_j = 150 °C		-	1.5	3	
T_j = 25 °C, I_L = 50 mA, V_{bb} = 6 V		-	2	5	
Nominal load current[2] Device on PCB [1] T_a = 85 °C , $T_j \leq$ 150 °C	$I_{L(nom)}$	0.2	-	-	A
Turn-on time[3] V_{IN} = V_{bb} to 0V to 90% V_{OUT}	t_{on}				µs
R_L = 270 Ω		-	-	125[4]	
R_L = 270 Ω, V_{bb} = 13.5 V, T_j = 25 °C		-	45	100	
Turn-off time[3] V_{IN} = 0V to V_{bb} to 10% V_{OUT}	t_{off}				
R_L = 270 Ω		-	-	175[4]	
R_L = 270 Ω, V_{bb} = 13.5 V, T_j = 25 °C		-	40	140	
Slew rate on[3] V_{IN} = V_{bb} to 0V 10 to 30% V_{OUT}	dV/dt_{on}				V/µs
R_L = 270 Ω		-	-	6[4]	
R_L = 270 Ω, T_j = 25 °C, V_{bb} = 13.5 V		-	1.3	4	
Slew rate off[3] V_{IN} = 0V to V_{bb} 70 to 40% V_{OUT}	$-dV/dt_{off}$				
R_L = 270 Ω		-	-	8[4]	
R_L = 270 Ω, T_j = 25 °C, V_{bb} = 13.5 V		-	1.7	4	

[1]Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6 cm2 (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air.

[2]Nominal load current is limited by the current limitation (see page 5)

[3]Timing values only with high input slewrates, otherwise slower.

[4]not subject to production test, specified by design

Electrical Characteristics

Parameter at T_j = -40...150 °C, V_{bb} = 9...42 V unless otherwise specified	Symbol	Values min.	Values typ.	Values max.	Unit
Operating Parameters					
Operating voltage	$V_{bb(on)}$	4.9	-	60	V
Standby current Pin1 = open	$I_{bb(off)}$	-	2	10	µA
Protection Functions[1]					
Initial peak short circuit current limit (see page 14) T_j = -40 °C, V_{bb} = 13.5 V, t_m = 100 µs T_j = 25 °C T_j = 150 °C	$I_{L(SCp)}$	 - - 0.2	 - 0.9 -	 1.2 - -	A
Repetitive short circuit current limit $T_j = T_{jt}$	$I_{L(SCr)}$	-	0.7	-	
Output clamp (inductive load switch off) at $V_{OUT} = V_{bb} - V_{ON(CL)}$, I_{bb} = 4 mA	$V_{ON(CL)}$	60	-	-	V
Overvoltage protection I_{bb} = 1 mA	$V_{bbin(AZ)}$	62	68	-	
Thermal overload trip temperature	T_{jt}	150	-	-	°C
Thermal hysteresis	ΔT_{jt}	-	10	-	K

[1] Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as "outside" normal operating range. Protection functions are not designed for continuous repetitive operation.

Electrical Characteristics

Parameter at T_j = -40...150 °C, V_{bb} = 9...42 V unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
Input					
Off state input current $V_{OUT} \leq 0.1$ V T_j = 25 °C, R_L = 270 Ω T_j = 150 °C	$I_{IN(off)}$	 - -	 - -	 0.05 0.04	mA
On state input current (Pin1 grounded)[1)]	$I_{IN(on)}$	-	0.3	1	
Input resistance	R_I	0.5	1	2.5	kΩ

Reverse Battery

Parameter	Symbol	min.	typ.	max.	Unit
Continuous reverse drain current T_C = 25 °C	I_S	-	-	0.2	A
Drain-source diode voltage ($V_{OUT} > V_{bb}$) I_F = 0.2 A, $I_{IN} \leq$ 0,05 mA	$-V_{ON}$	-	600	-	mV

[1]Driver circuit must be able to drive currents > 1mA.

EMC-Characteristics

All EMC-Characteristics are based on limited number of sampels and no part of production test.

Test Conditions:

If not other specified the test circuitry is the minimal functional configuration without any external components for protection or filtering.

Supply voltage:	V_{bb} = 13.5V	Temperature:	T_a = 23 ±5°C ;
Load:	R_L = 220Ω		
Operation mode:	PWM DC On/Off	Frequency:	100Hz / Duty Cycle: 50%
DUT-Specific.:	-		

Fast electrical transients

Acc. ISO 7637

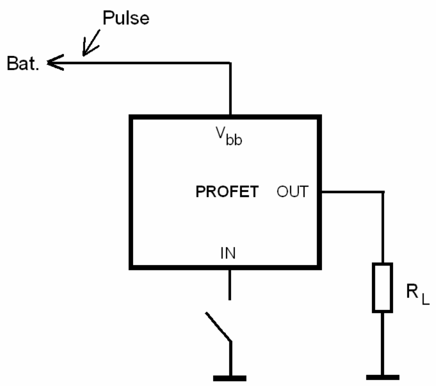
Test Pulse	Test Level	Test Results		Pulse Cycle Time and Generator Impedance
		On	Off	
1	-200 V	C	C	500ms ; 10Ω
2	+200 V	C	C	500ms ; 10Ω
3a	-200 V	C	C	100ms ; 50Ω
3b	+ 200 V	C	C	100ms ; 50Ω
4[1)]	-7 V	C	C	0,01Ω
5	175 V	E (150V)	E (150V)	400ms ; 2Ω

The test pulses are applied at V_{bb}

Definition of functional status

Class	Content
C	All functions of the device are performed as designed after exposure to disturbance.
E	One or more function of a device does not perform as designed after exposure and can not be returned to proper operation without repairing or replacing the device. The value after the character shows the limit.

Test circuit:

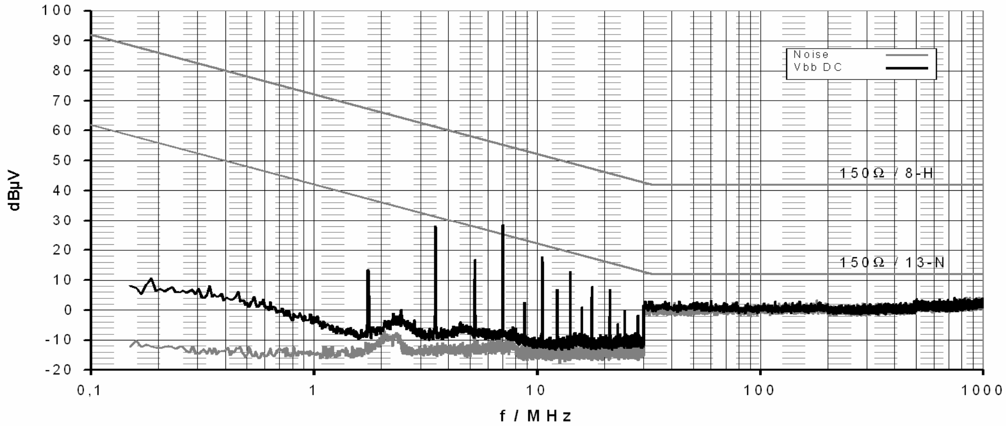


[1]Supply voltage V_{bb} = 12 V instead of 13.5 V.

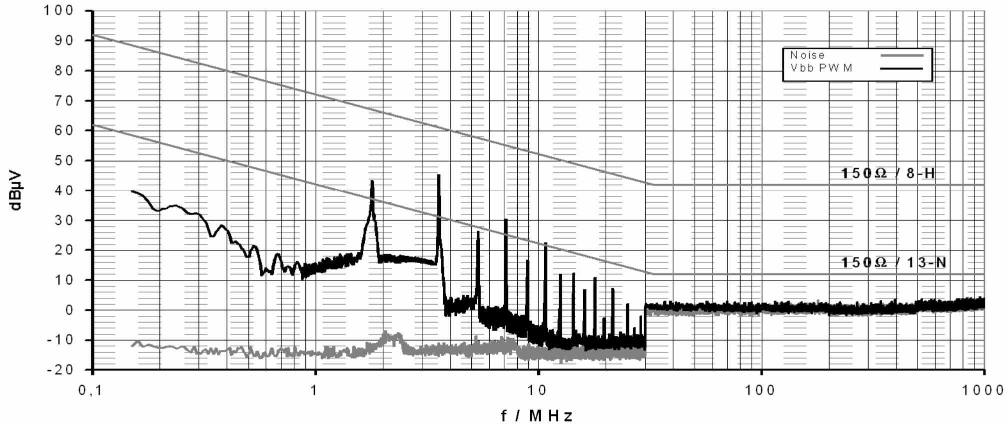
Conducted Emission

Acc. IEC 61967-4 (1Ω / 150Ω method)

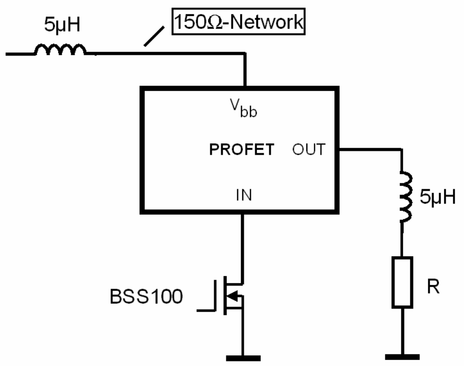
Typ. V_{bb}-Pin Emission at DC-On with 150 Ω-matching network



Typ. V_{bb}-Pin Emission at PWM-Mode with 150 Ω-matching network



Test circuit:



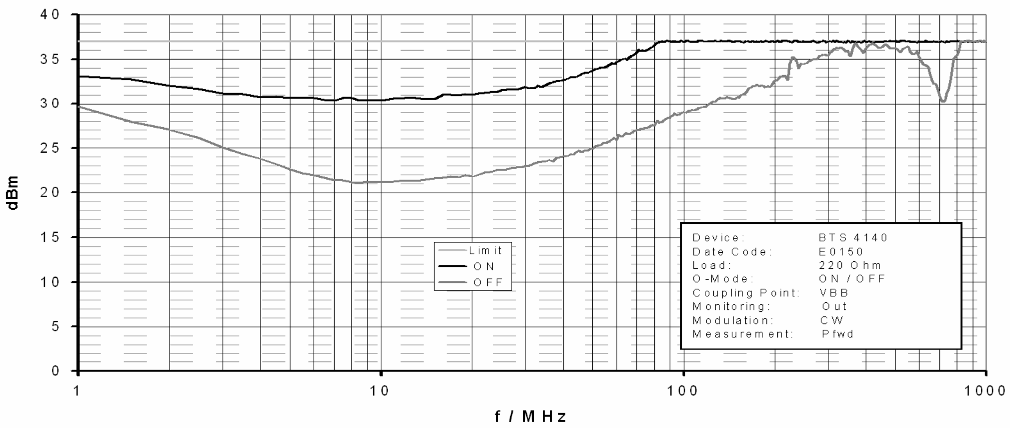
For defined decoupling and high reproducibility a defined choke (5µH at 1 MHz) is inserted between supply and V_{bb}-pin.

Conducted Susceptibility

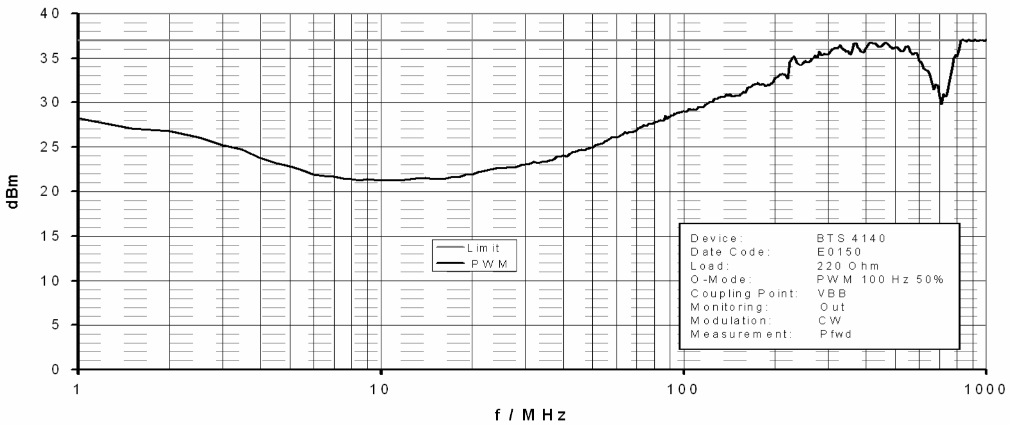
Acc. 47A/658/CD IEC 62132-4 (Direct Power Injection)

Direct Power Injection: Forward Power CW
Failure criteria: Amplitude and frequency deviation max. 10% at Out

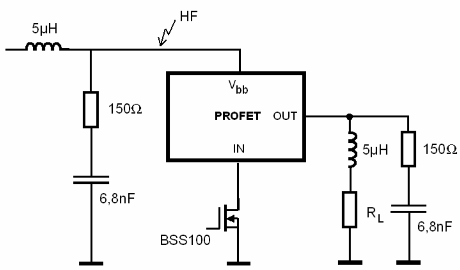
Typ. V_{bb}-Pin Susceptibility at DC-On/Off



Typ. V_{bb}-Pin Susceptibility at PWM-Mode

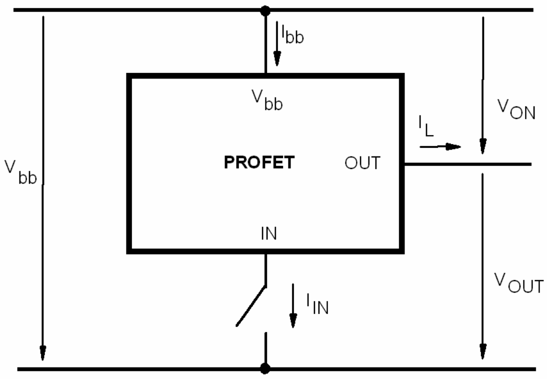


Test circuit:

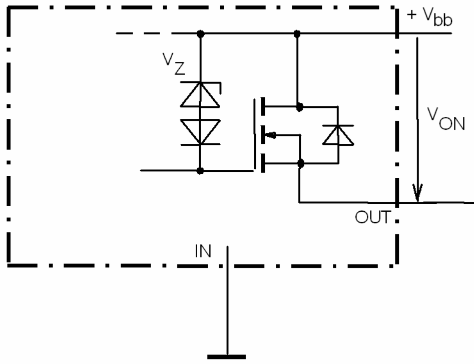


For defined decoupling and high reproducibility the same choke and the same 150Ω -matching network as for the emission measurement is used.

Terms

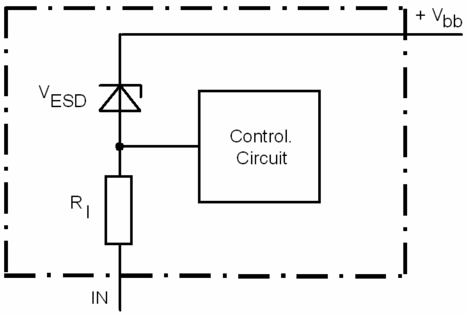


Inductive and overvoltage output clamp

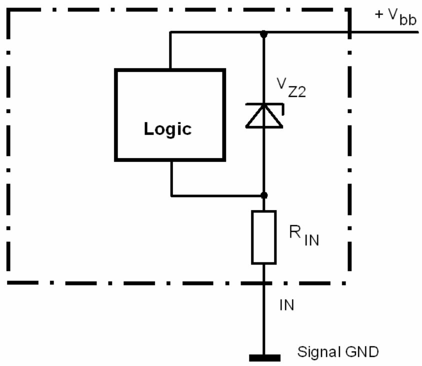


V_{ON} clamped to 60 V min.

Input circuit (ESD protection)

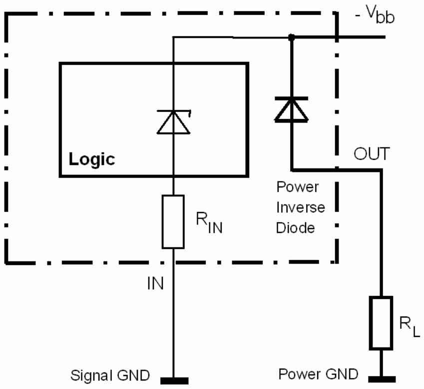


Overvoltage protection of logic part



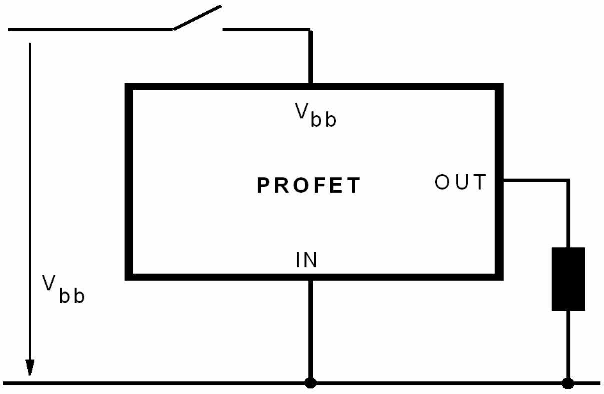
$V_{bb,AZ} = V_{Z2} + I_{bb} * R_{IN} = 62\text{V min.}$

Reverse battery protection

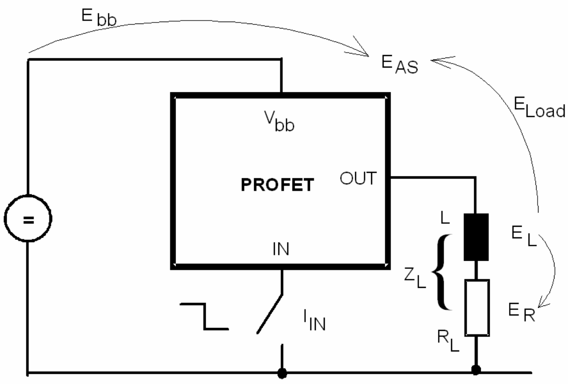


R_I=1kΩ typ., Temperature protection is not active during inverse current.

V_{bb} disconnect with charged inductive load



Inductive Load switch-off energy dissipation



Energy stored in load inductance: E_L = ½ * L * I_L^2

While demagnetizing load inductance, the enérgy dissipated in PROFET is

$E_{AS} = E_{bb} + E_L - E_R = V_{ON(CL)} * i_L(t)\ dt$,

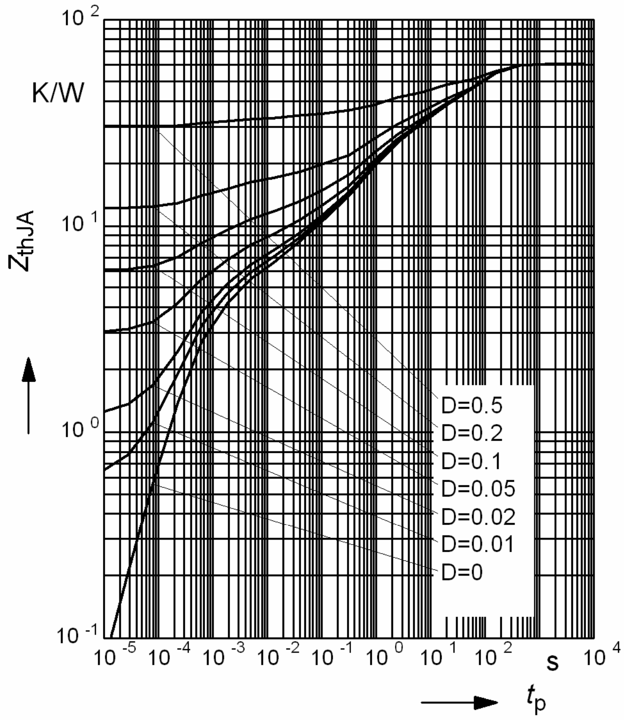
with an approximate solution for $R_L > 0\Omega$:

$$E_{AS} = \frac{L}{R_L} \cdot \left(V_{bb} + \left|V_{OUT(CL)}\right|\right) \cdot \left[\frac{-\left|V_{OUT(CL)}\right|}{R_L} \cdot \ln\left(1 + \frac{R_L \cdot I_L}{\left|V_{OUT(CL)}\right|}\right) + I_L \right]$$

Typ. transient thermal impedance

Z_{thJA}=f(t_p) @ 6cm² heatsink area

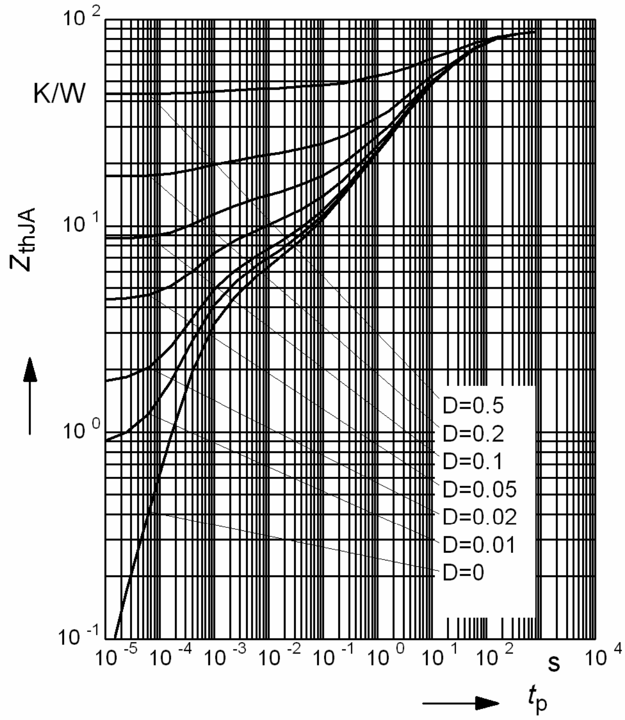
Parameter: $D=t_p/T$



Typ. transient thermal impedance

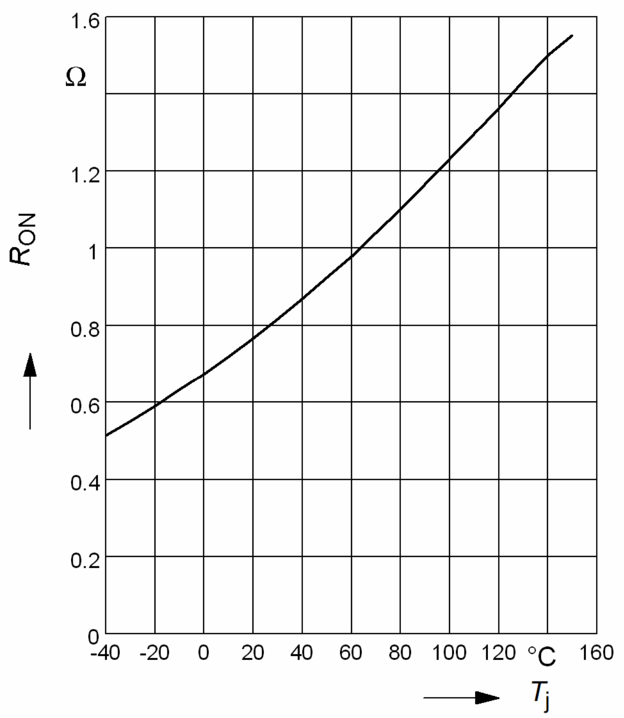
Z_{thJA}=f(t_p) @ min. footprint

Parameter: $D=t_p/T$



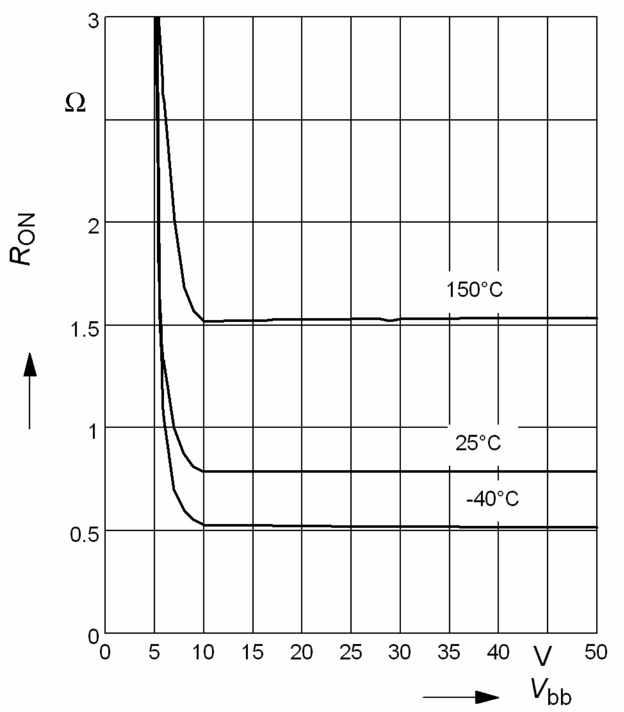
Typ. on-state resistance

R_{ON} = f(T_j) ; V_{bb} = 9V ; Pin1 grounded; I_L=150mA



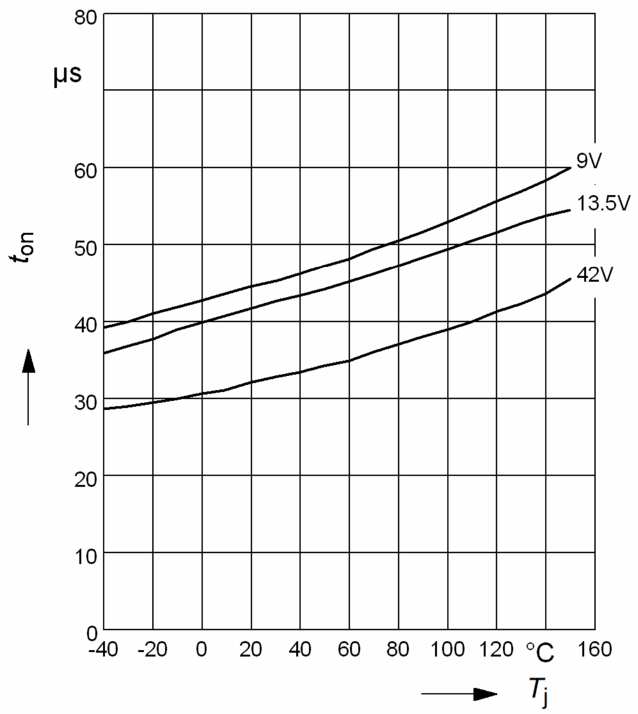
Typ. on-state resistance

R_{ON} = f(V_{bb}); I_L = 150mA ; Pin1 grounded



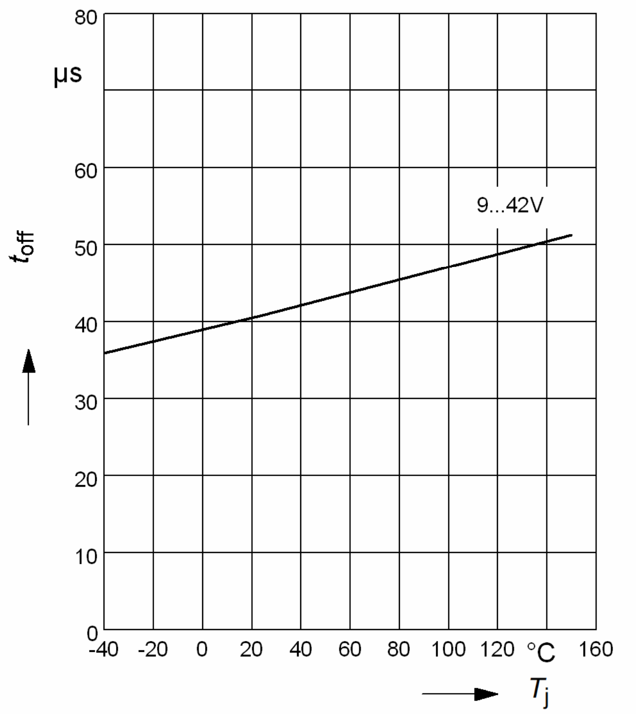
Typ. turn on time

$t_{on} = f(T_j)$; $R_L = 270\Omega$



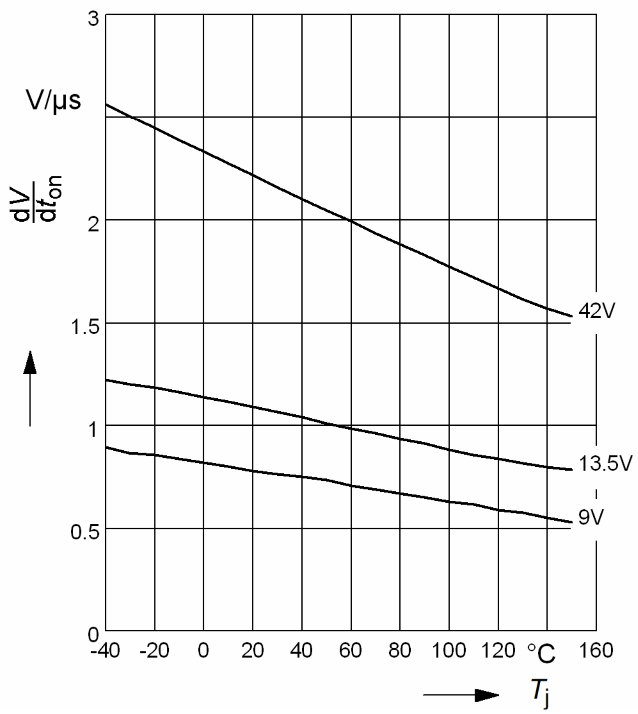
Typ. turn off time

$t_{off} = f(T_j)$; $R_L = 270\Omega$



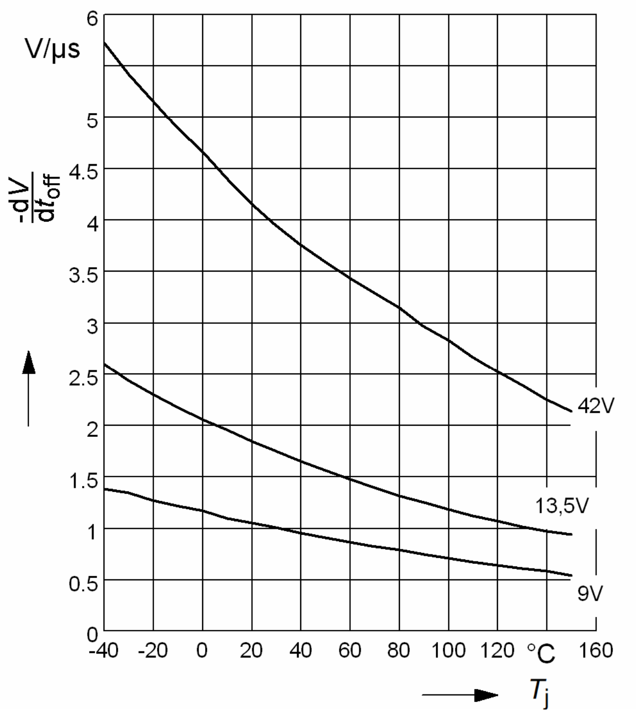
Typ. slew rate on

$dV/dt_{on} = f(T_j)$; $R_L = 270\ \Omega$



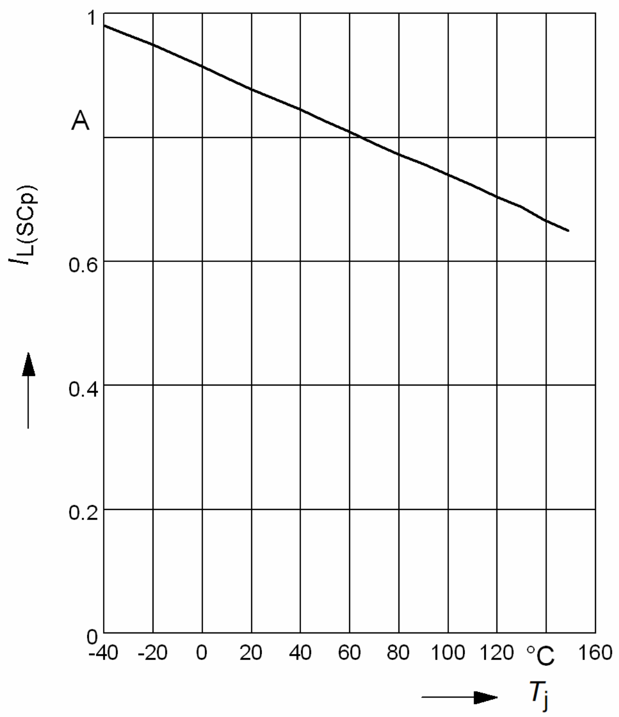
Typ. slew rate off

$dV/dt_{off} = f(T_j)$; $R_L = 270\ \Omega$



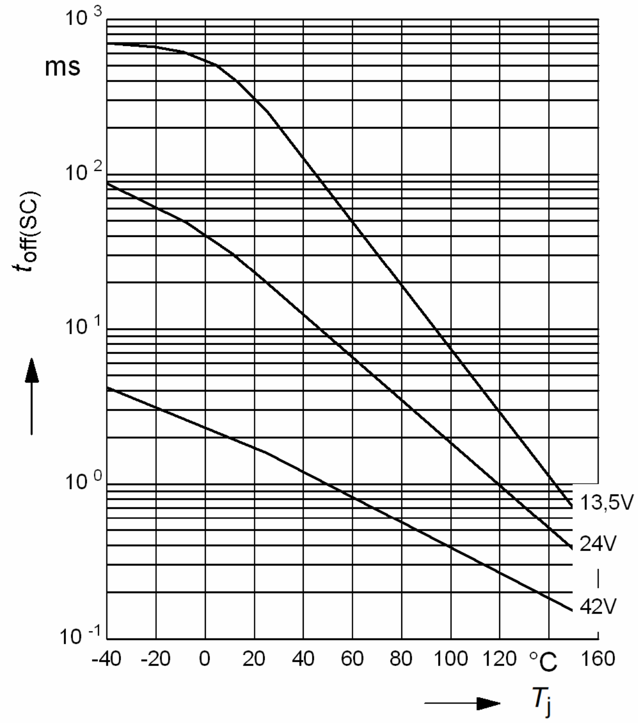
Typ. initial peak short circuit current limit

$I_{L(SCp)} = f(T_j)$; V_{bb} = 13,5 V; t_m = 100 µs



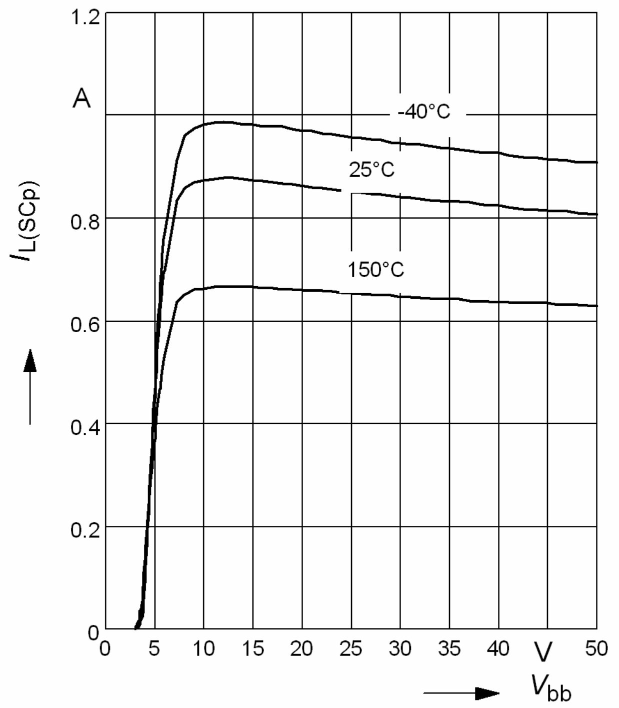
Typ. initial short circuit shutdown time

$t_{off(SC)} = f(T_{j,start})$



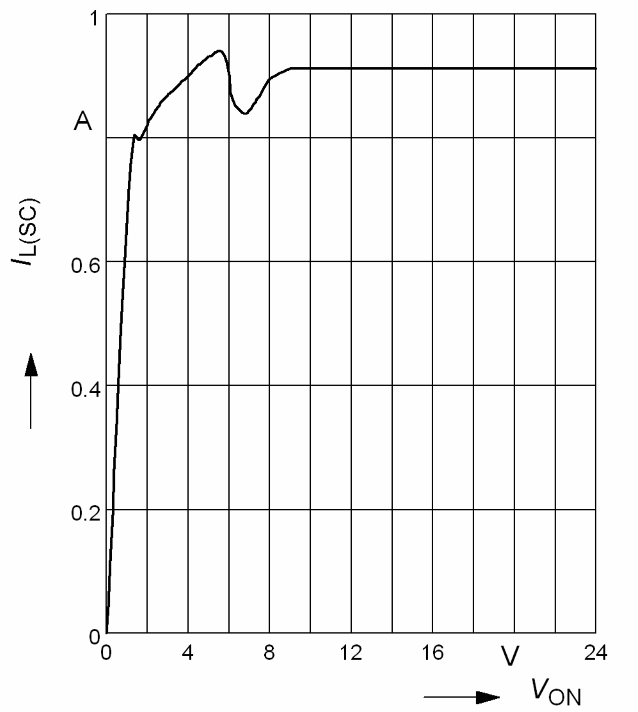
Typ. initial peak short circuit current limit

$I_{L(SCp)} = f(V_{bb})$; t_m = 100 µs



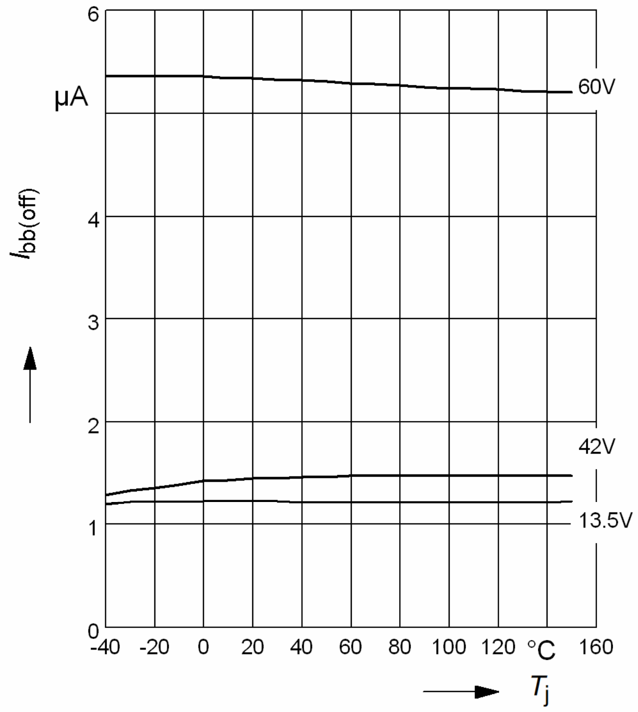
Typ. current limitation characteristic:

$I_{L(SC)} = f(V_{ON})$, V_{bb} = 13,5V



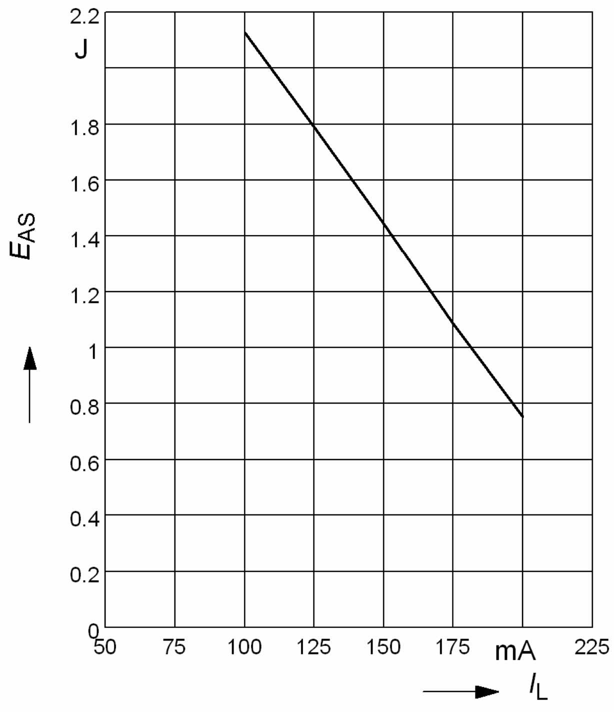
Typ. standby current

$I_{bb(off)}$ = f(T_j) ; Pin1 open



Maximum allowable inductive switch-off energy, single pulse

E_{AS} = f(I_L); T_{jstart} = 150°C



Timing diagrams

Figure 1a: Vbb turn on:

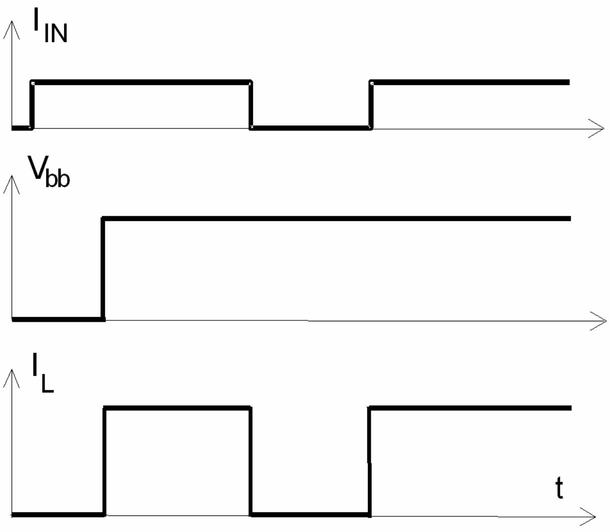


Figure 2b: Switching a lamp

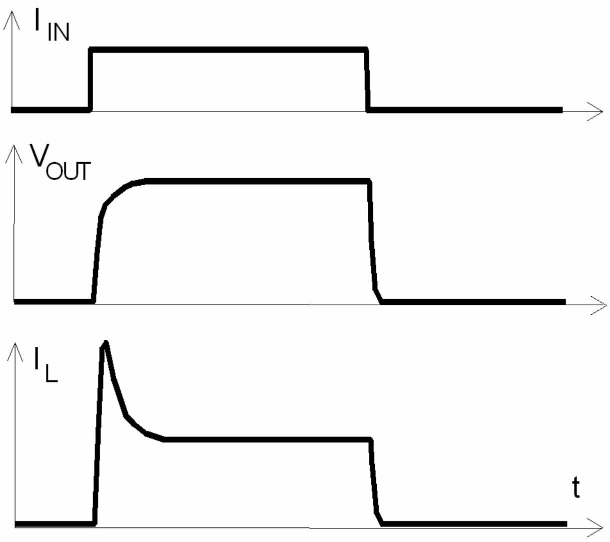


Figure 2a: Switching a resistive load, turn-on/off time and slew rate definition

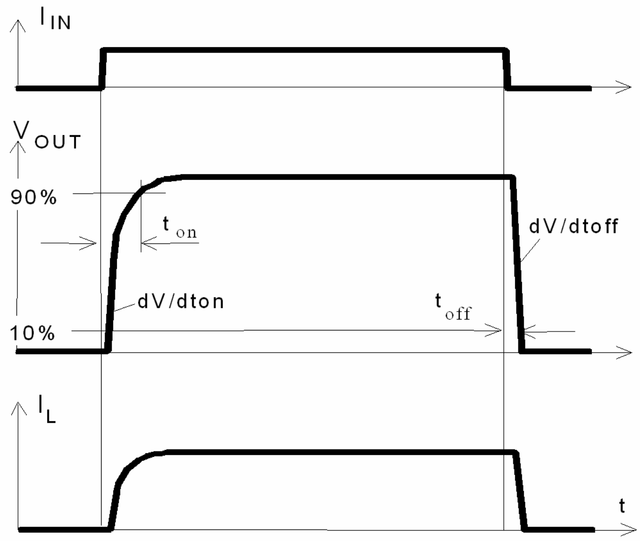


Figure 2c: Switching an inductive load

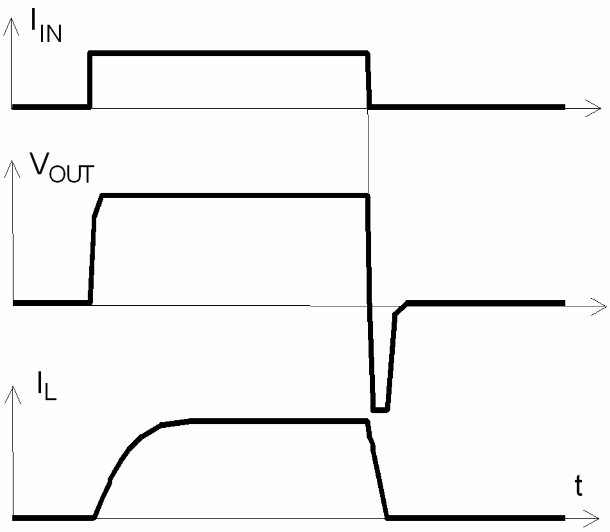
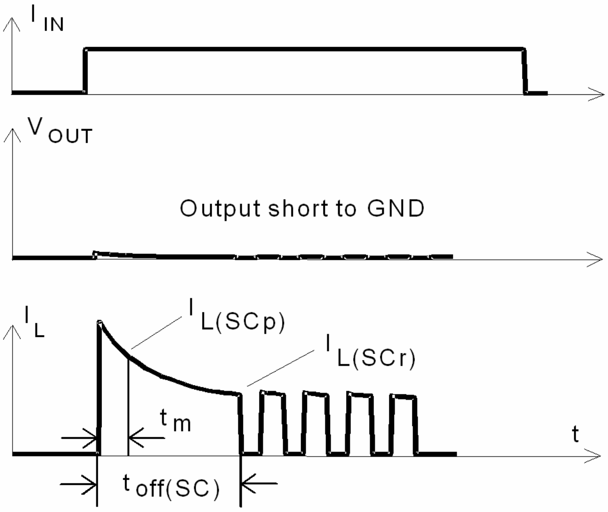


Figure 3a: Turn on into short circuit,
shut down by overtemperature, restart by cooling



Heating up of the chip may require several milliseconds, depending on external conditions.

Figure 3b: Short circuit in on-state
shut down by overtemperature, restart by cooling

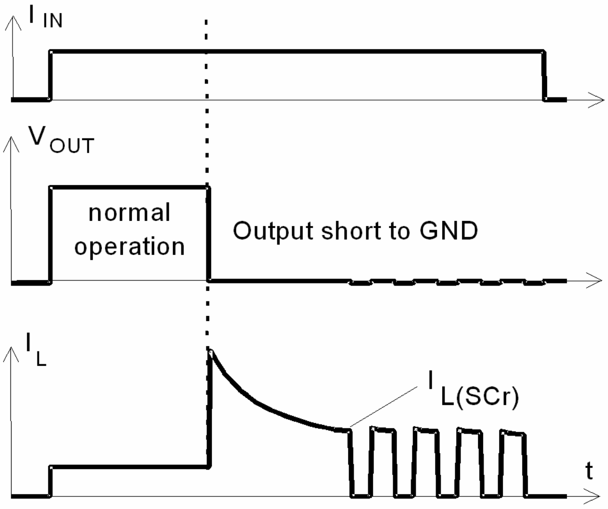
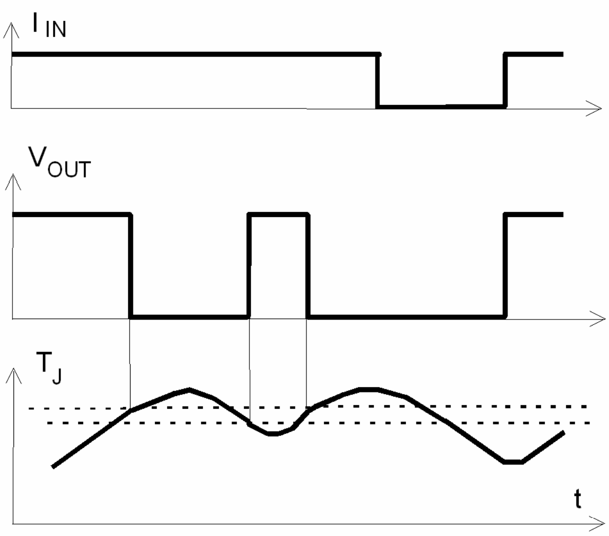


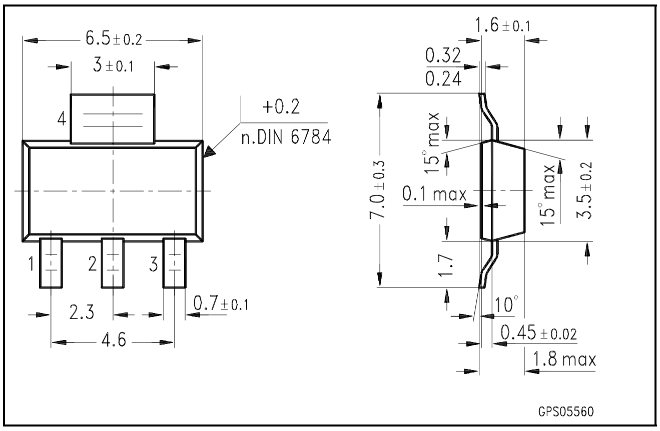
Figure 4: Overtemperature:
Reset if $T_j < T_{jt}$



Package and ordering code:

Type	Ordering code	Package
ITS 4140N	**SP000240073**	PG-SOT223

all dimensions in mm.



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